HIGH-SPEED RAIL SAFETY ASSURANCE PROGRAM

HIGH-SPEED RAIL SAFETY ASSURANCE PROGRAM

SUMMARY

The FRA has been working since 1988 to ensure that all proposed high-speed ground transportation (HSGT) projects will result in a very high level of safety for riders and the American public in general. For the last 5 years, the goal has been to anticipate regulatory needs, then work toward ensuring the necessary research results are in place, and finally to facilitate timely and effective rulemaking that does not needlessly inhibit technology advancements. One key to assuring the safety of new technology applications is to undertake system level analysis commonly referred to as system safety analyses. During the last 5 years two projects, a maglev system in Florida, the Transrapid, and a high-speed train in Texas, the Texas TGV, were addressed by the FRA in this manner. For both projects, the FRA practiced what can be referred to as project-accompanying-safety assurance. Teams of FRA and FRA support personnel have worked with project teams to minimize risk at the system level in the design process by identifying all system risk elements that can be “designed out of the system”. When this was not possible, appropriate mitigation methods to control the risk have been pursued. This total system approach is now also being adopted in FRA’s traditional areas of regulation for intercity freight and passenger service.

To identify key research areas for HSGT, the FRA enlisted the help of the National Academy of Science’s Transportation Research Board to convene workshops into the safety-related research needs for high-speed ground transportation in 1991 and 1993. These workshops brought together industry, labor, and academia in a climate of collaboration to reach consensus on important topic areas to focus limited federal research dollars.

Eurostar Traveling through Belgium

As a result of these workshops and ongoing input from other stake holders and FRA participation in relevant TRB and other industry sponsored standing committees, key research topic areas such as collision avoidance, accident survivability, and emergency preparedness were identified and well developed when the FRA began regulatory considerations in these areas.

Today, more than ever, the goal of this work is to continue to develop the necessary basis for timely, efficient and effective rulemaking by the FRA for HSGT systems. With the approaching delivery of Amtrak’s new high-speed Trainsets for 150 mph operation on the Northeast Corridor in 1999, and the move towards 125 mph operation on New York State’s Empire Corridor and other state initiatives towards high-speed rail, the need is real.

FRA Project Team Reviews TGV Power Car Safety Design Elements at GEC Alsthom’s (now Alstom) Locomotive Assembly Plant.

GEC Alsthom's TBL2 Automatic Train Control Test Car

As part of the ongoing effort to review underway and planned research, a formal reassessment of the High-Speed Ground Transportation Safety Program is planned for FY 1999. This will be an internal review and will be based upon a format of a structured program risk analysis to determine how well current research projects and priorities are focused on current and future potential research needs.

The trend of incorporating broad aspects of the program into ongoing track, vehicle, and systems research and development will continue. Specifically, those areas where the overlap between a high-speed focus and the "traditional" railroad focus has become significant will continue to be moved into the latter area to avoid any duplication of effort. Areas unique to high-speed operations or not covered under other programs but which are necessary for ensuring the safety of high-speed operations will be continued or expanded. Some examples of these types of projects include items that play heavily in an HSGT system risk perspective such as fire safety and emergency preparedness, crash safety assurance during high-energy collisions, human factors for high-speed train operations, aerodynamics and noise generation, and platform safety. In addition, exploiting the synergies between the various FRA research initiatives will continue to be stressed.

The major HSGT issues/risk factors affecting train safety that are topics of FRA research include the following:

Accident Avoidance

- Maintaining adequate train-to-train separation and reducing the likelihood of grade crossing accidents and right-of-way intrusion via signals and train control, operational scenarios, and human factors considerations.
- Maintaining adequate track and right-of-way quality for type of operation(s) via construction standards, maintenance and inspection standards, and track condition implications on vehicle/guideway dynamics.
- Reducing vehicle-caused derailments by addressing train handling, train make-up, and vehicle suspension condition implications on vehicle/guideway dynamics.
- Minimizing the environmental and operational impacts of EMF, noise, aerodynamic/platform safety.

Accident Response

- Ensuring passenger and crew safety in the event of an accident
  - Crash survival - structural and interior layout designs
  - Post-crash survival - fire safety and emergency access
- Ensuring adequate evacuation plans and emergency response
  - External - derailment sites and the general population
  - Internal - passengers and crew

The HSGT Safety program is focused on accident avoidance and response in three major areas outlined in the remainder of this section. These are:

- System Level Issues
- Passenger Vehicles
- Track and Right-of-Way

SYSTEM LEVEL ISSUES

SYSTEM SAFETY AND EMERGENCY PREPAREDNESS

In December of 1993, a report entitled, *Recommended Emergency Preparedness Guidelines for Passenger Trains*, was published and has since served as a valuable tool for Amtrak and all operators of commuter rail systems. The information contained in this report also has served as an important basis for developing comprehensive passenger equipment safety standards that include emergency preparedness and response issues for high-speed ground systems. Staff familiar with this work has participated in the emergency preparedness working group of the safety standards development initiative of the FRA Office of Safety. In a related effort, the FRA has consulted with the Fire Protection Training Division of Texas A & M University as it developed course material in conjunction with Amtrak for a passenger train emergency response course that includes actual passenger cars as part of the training initiative.

Evacuation Drill in Pennsylvania Station, New York City

RESEARCH STATUS

Support in this area, underway since 1989, has included a review of two now-terminated projects - the German Transrapid System (Florida) and the French TGV (Texas), as well as the X2000, ICE, and Talgo trains deployed for test and revenue demonstration service on the Northeast Corridor and other Amtrak intercity lines. The research in this area realized the following results:

- Developed an Emergency Preparedness Guidelines Report for Passenger Trains based on previous work on Federal Transit Administration projects performed at the Volpe Center.
- Worked with Amtrak and the Texas Transportation Institute at Texas A&M to develop a course on Passenger Train Emergency Response.
- Initiated a 3-Phase Fire Hazard Analysis for U.S. Passenger Train Systems and completed Phase-1: Evaluation of Current Materials in Bench-Scale Tests.
- Monitored research on electromagnetic fields and potential associated health effects.
- Initiated development of corridor risk analysis methodology to prioritize train control deployment.
- Documented vital software validation and verification methods used worldwide in safety critical industries (nuclear, health, and transportation).

KEY FINDINGS

The effects of highly automated systems on human operators and the resulting training and qualification implications for operators have been determined.

FUTURE RESEARCH

Safety analysis support will continue for the recently placed order for the new high-speed Northeast Corridor trainsets by Amtrak, and the FDOT/FOX high-speed train project utilizing TGV technology in Florida as well as the continuing Talgo technology demonstrations in the Pacific Northwest.

AUTOMATION LEVELS/ METHODS AND OPERATOR RESPONSE

Refer to Human Factors section for more details.

Advanced Train Control Systems and Accident Avoidance - Advanced Train Control Systems use a multiplicity of software-driven, radio-frequency data distribution transceivers, transponders, sensors and actuators in many wayside and train-borne railway signal and control systems. These software-driven components present critical interfaces among signals, communications, and train control functions. Although digital automatic control systems offer potential increased capability, availability, dependability, and cost-effectiveness, they are also more complex. Furthermore, they consist of a combination of hardware and software that are interconnected in complex networks and process complex software procedures. Increasingly complex interactions among these functions have the potential to create unknown and potentially unsafe failure modes. Research is being conducted to understand these failure modes and to develop procedures for validating, verifying, inspecting, testing, and evaluating the safety of these devices and systems. In September 1995, two reports, *Safety of High Speed Ground Transportation Systems: Analytical Methodology for Safety Validation of Computer Controlled Subsystems: Vol 1. State-of-the-Art and Assessment of Safety Verification/Validation Methodologies* and *Safety of High Speed Ground Transportation Systems: Analytical Methodology for Safety Validation of Computer Controlled Subsystems: Vol 2. Development of a Safety Validation Methodology*, were published. In May 1993, *Verification Methodology for Fault-Tolerant, Fail-Safe Computers Applied to Maglev Control Computer Systems* was published.

This project area is intended to lead to guidelines and recommended practices for validation, verification, inspection, and testing of electrical and electronic hardware and software systems affecting train control safety.

RESEARCH STATUS

Fail-safe System Performance and Validation Requirements - The development and usage of microprocessors and computers has resulted in significant increased use and reliance on microprocessors-based products in numerous safety critical signal, control, and interlocking systems. To satisfy railroads' safety, reliability, and maintainability concerns of this new technology, Working Group E-3, *Signal Controls and Safety Assurance Applications*, of the Association of American Railroads (AAR), Communication and Signal (C&S) Division (now part of AREMA) has focused on the development of guidelines, specifically Section 17 of the AAR C&S Manuals, *Quality Principals, Software Based Equipment*. The objective of this guideline is to develop a quality assurance program that, if implemented comprehensively, will assure safety, availability, and reliability of railroad operations. As of January 1, 1998, the AAR C&S Division manuals and committees have been transferred to the American Railway Engineering and Maintenance-of-Way Association (AREMA).

In addition to the AAR and AREMA efforts, the IEEE Vehicular Technology/Rail Transit Vehicle Interface Standards Committee established Working Group 2 to develop the minimum set of performance and functional requirements necessary to achieve an acceptable level of safety, performance, availability, and operations for Communications-Based Train Control (CBTC) systems. The goal of the standard is to enable transit agencies to streamline their CBTC procurement, enabling suppliers to focus their development efforts, and minimize the amount of new design required for each new application.

The IEEE Vehicular Technology/Rail Transit Vehicle Interface Standards Committee also established Working Group 4 to develop a draft standard for the verification of safety for process-based systems used in rail transit control. The introduction of integrated circuits, microprocessors, and software has increased the complexity of safety-critical systems potentially beyond the ability of traditional analyses to verify their safe operation in the event of hardware component failures and software errors. The purpose of this standard is to provide agreed upon verification procedures and analyses which, if implemented comprehensively, will verify the level of safety assurance achieved in a given system is adequate to meet the stated safety objectives. FRA staff have actively participated in and contributed their technical expertise to the standard development efforts of the AAR and IEEE.

KEY FINDINGS

One safety validation and verification methodology under consideration by the FRA uses a three-layered approach for dealing with hardware and software faults. Validation essentially uses fault avoidance techniques during the specification, design, and development phases to ensure that inherent faults do not exist. Fault removal techniques are used during testing and verification to eliminate faults that were not avoided. Fault-tolerance techniques may be used in operation to detect and recover in real-time from those faults that are not eliminated by fault avoidance and fault removal techniques.

To date, the IEEE draft standard has focused on the analysis required for verification. It includes a methodology for intrinsic fail-safe design, checked-redundancy, N-version programming, diversity and self-checking, and numerical assurance. There are three levels of analysis - conceptual, functional, and implementation. The conceptual portion of the analysis is where differences occur in the way analyses are performed. This is evident in the safety assurance concept and the dependent factors. The safety of a system is dependent on the correctness of software. Suppliers are required to show that software is free of errors that will not cause unsafe failures. However, there is no definitive means of ensuring that software is correct, or to show that there is a boundary on the number of software errors. Recognizing that there is a set of failure modes that will likely always exist because software will likely never be correct, the question remains how we can make software fail-safe.

Typically there is a fine line between a fail-safe calculation and shutting down the system. Availability and reliability must be balanced. The use of computer off-the-shelf (COTS) operating systems are cost effective, but they are not developed under the same quality assurance standards as safety-critical software. The issue is how to implement reliable computing using unreliable components, and, how to maintain distributed systems without errors.

Recognizing that hardware and software are expected to fail at some time during the system life, and that a system must be able to tolerate these faults while maintaining normal operations, or in the exceptional worst case scenario, by failing in a safe manner. The goal is for redundancy to be managed in such a way that a vehicle can be dispatched reliably with failures in order to achieve greatly improved availability, dependability, and system productivity with a minimum number of vehicles.

FUTURE RESEARCH

Future work in this area will consist of continued support to industry standards development and, where necessary, support to regulatory actions. Safety analyses related to the Next Generation High-Speed Rail Positive Train Separation and Positive Train Control development initiatives will be conducted (see Part B, Next Generation High-Speed Rail). The applicability of the validation and verification methodology being developed will be demonstrated initially on a laboratory model and later on a real control system such as a Positive Train Control system. This demonstration will be monitored by the AREMA C&S Division Technical Committee E. Other possible directions for work in this area may include analysis of other critical automated systems such as remote/automated brake inspection systems and remote monitoring of truck hunting that may lead to unstable vehicle guideway dynamics at high speed.

Environmental, Safety, and Health Effects of Electromagnetic Fields and Radiation - With the advent of high-speed rail (HSR) improvements and upgrades in rail infrastructure, vehicles, and communications and control technologies, the U.S. railroad environment is rapidly changing. Increased electrification, automation and reliance on distributed communication and control systems for positive train control systems are changing the rail operating environment. Expanded rail electrification and HSR systems and services in congested corridors promise improved speed and energy efficiency with added environmental benefits. However, lingering public concern with potentially adverse health effects of electromagnetic fields (EMF) and radiation (EMR) must be proactively addressed to successfully deploy new rail technologies.

Extremely low frequency (ELF) EMF near the power frequency (60 cycles and harmonics), and broad-band radio frequency radiation (RFR) can become of concern to safe rail operability due to electromagnetic interference (EMI) and lack of subsystem compatibility (EMC), as well as to the health and environmental quality for rail workers, passengers and the public. EMF and EMR are a continuing concern in advanced rail and transit transportation. They were a major issue in recent litigation on the Northeast Corridor Improvement Project, and key concerns in previous Florida Maglev and Texas HSR proposals and environmental assessments.

In 1990, in response to Congressional and public concerns, the FRA initiated an EMF research program in order to characterize EMF emissions associated with conventional, advanced, and prototype rail systems, such as HSR and maglev, and to identify and assess potential health and safety effects and cost-effective options for EMF control, mitigation, and regulation. The Volpe Center has managed this program for the FRA since 1990 as an integral part of the safety analysis and regulatory development support for maglev and other advanced rail technologies, in partnership with EPA and DOE Argonne National Labs, and with contract support. The EMF research program also focused on potential operational safety impacts of EMI and EMC. Research findings have informed and supported rail development planning, environmental impacts, and safety regulatory development. A data base resulted from an EMF survey program to enable comparison of rail technologies and aid in preventing or mitigating potential environmental, safety, and health (ESH) hazards through siting, design, and engineered materials, or through operation and exposure management.

RESEARCH STATUS

Over the past 5 years, accomplishments in this area have included the following:

- Developed a portable EMF test instrumentation and a tailored test protocol for a comprehensive dynamic characterization of the rail EMF system and environment.
- Performed an extensive EMF survey of and developed an EMF database for existing and emerging rail and transit electro-technologies and systems (control centers, electric substations, passenger stations, and under and near the catenary or third rail in locomotive cab and passenger cars) including the TR-07 German maglev, the French TGV, the Northeast Corridor (conventional diesel-electric, electrified 25 Hz and 60 Hz portions, and the Metro-North and North Jersey Coast transit), and transit systems in Washington and Boston (light rail with third rail D.C. or catenary systems, electric trolley).
- The EMF dynamic characteristics of maglev and emerging HSR systems were compared with existing transit and electrified rail systems, and with other common environmental (home, work, and office) EMF sources.
- Comparative data on EMF characteristics of each transit and rail electro-technology were developed, enabling designers and operators to identify and prevent or mitigate any potential safety hazards or public health concerns.
- In the absence of Federal EMF guidelines, development of draft regulatory guidelines for EMF emissions and exposure of passengers, public, and personnel from maglev and HSR systems was undertaken for proposed U.S. applications (such as the Orlando Maglev Project, Texas TGV, the Northeast Corridor Improvement Project (NECIP), Amtrak's NEC HS trainsets, and the FDOT/FOX Project.)
- The National Maglev Initiative program (1990-1994) also addressed design and mitigation options to minimize passengers' exposure to EMF with active or passive magnetic shielding. Such studies included the maglev technology and system concept definition; General Electric Corporation assessed the cost and performance impacts of active and passive shielding options for superconducting maglev designs; Foster Miller, Inc. demonstrated a novel high temperature superconductor shielding concept, offering active magnetic field control options for maglev; and Intermagnetics General Corporation (IGC) explored modeling of stray fields and magnetic shielding options for maglev using superconducting magnets.

- Thirteen published reports on EMF issues and findings and chapters on EMF/EMI/EMC assessment, mitigation, and safety guidelines for the operating environment of high-speed ground transportation systems have resulted from this research program, as well as expert support to other programs (e.g., work rules, electrical safety, interference-free design of GRMS, and the Environmental Impact Statement for NECIP).

KEY FINDINGS

- New rail systems did not exhibit unusual EMF intensity, but have unique variability in time and space, and frequency spectra (signatures) typical of the electro-technology employed.
- The German TR-07 maglev technology did not produce unusually strong EMF and costly shielding or other active field management was unnecessary.

Phased Array - Maglev Noise Monitoring at Emsland Test Facility in Germany

FUTURE RESEARCH

Environment, Safety and Health Effects of Broad Band EMF/EMR - Continuing monitoring and adoption of national and international research, policies, regulatory standards and control options to address ESH issues for new technology developments (FDOT/FOX, HSST maglev, and introduction of PTC and Global Positioning System-aided advanced train control system), to ensure effective monitoring, prevention, and mitigation of potential ESH effects.

Evaluation of EMF/EMR - Basic research and development to aid the improvement and electrification of transit, commuter, and high-speed rail will continue. Evaluation of the EMF associated with high-speed rail operations, including Amtrak's American Flyer and FDOT/FOX also will continue. The focus of this effort will be on EMF/EMR modeling and measurement and on cost-effective engineered options for prevention, mitigation, and control in the rail environment.

Electrical Systems Safety and EMI/EMC - New technologies such as microprocessor-based controls, wayside distributed and onboard computers and sensors, the Global Positioning System, and wireless data transmission systems such as spread spectrum radio, are being introduced by the railroad industry. The circuitry in these systems is extremely sensitive to low-power-conducted-and-radiated EMI. EMC for safety-critical components and subsystems for communication, navigation, location, and control must be assured for safe rail operation. These technologies must be certified for safe operability for the full range of electromagnetic frequencies and sources found in an increasingly radio-polluted operating environment. New rail systems and technologies will be evaluated to ensure that they comply with industry-accepted best practice and EMI standards and to provide EMI/EMC/EMF characterization, test, and mitigation support as required.

Identification of Applicable Technical and Safety Standards - In order to comply with PL 104-113, The National Technology Transfer and Advancement Act of 1996, it may be necessary to establish a technical standards working group under the Railroad Safety Advisory Committee to identify, select, adopt, or adapt appropriate existing consensus or other professional organization technical personnel and public exposure safety standards for EMF and EMR emissions.

PASSENGER VEHICLES

Collision Avoidance and Accident Survivability Refer to the Train Occupant Safety Section for more details.

Fire Safety - Refer to the Train Occupant Safety Section for more details.

Advanced Braking Systems - Refer to the Rolling Stock Section, Equipment and Component Structural Integrity, for details on this topic.

TRACK AND RIGHT-OF-WAY

Track Structures at High Speed - In the area of track standards, a new initiative is underway to place two instrumented wheelsets under Amtrak's Track Geometry Car No. 10002. The objective of this research is to tie together known track geometry data with wheel/rail force data (via the instrumented wheelsets) and ride quality data (via instrumentation from accelerometers provided by the Next Generation High-Speed Rail Program) to develop realistic performance-based track geometry standards for high-speed operations. Track maintenance history and inspection results will also be a part of the overall data analysis/correlation efforts. This work is part of a cooperative effort with Amtrak to better understand the interactions between high-speed operations and track quality and follows up the various efforts completed during the demonstrations of the Swedish X2000 and the German InterCity Express (ICE) trains on the Northeast Corridor.

In the area of guideway strength, the major initiative is a multi-year program to better understand the phenomenon of track shift, a unique lateral movement of track under high-speed operations be it 200 mph stiff trucks or 150 mph steerable trucks. The report, *Safety of High Speed Ground Transportation Systems: Track Lateral Shift: State-of-the-Art Review,* was published in February 1996.

Photograph courtesy of Bombardier, Inc.
Transportation Equipment Group

Model development leading to a better understanding of the safety issues is currently underway and the analysis should be complete in FY 1998. This is discussed in more detail in the Track Lateral Shift for HSR Applications later in this section.

RESEARCH STATUS

- Developed initial guidelines for high-speed track structures in terms of stability \tab under high thermal and mechanical loadings.
- Initiated development of innovative track geometry measurement techniques based on correlations between ride quality measures and wheel/rail force measurements.
- Completed a draft report on a review of safety issues related to the operation and maintenance of electrified railroads.

All support in the safety area is oriented toward the realization that there are potentially serious safety implications of passenger service operating at much higher speeds and operating in mixed traffic and/or utilizing innovative technologies. The safety review of the Amtrak High-Speed Trainset Specification for the procurement of 18 (now 20) high-speed trainsets is consistent with this reality and is an example of multi-disciplinary safety analysis support of high-speed ground systems.

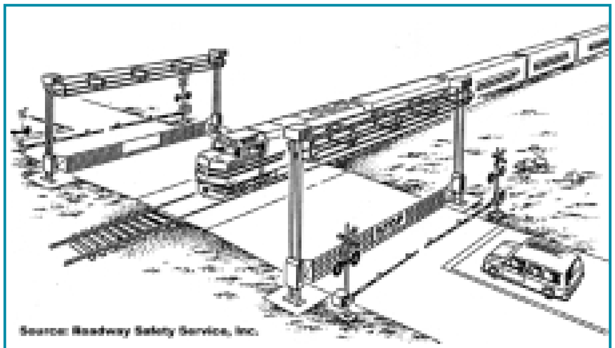
The Office of Research and Development provided guidance to the Office of Safety and Amtrak in areas such as brake system status monitoring, brake disk temperature limits, truck safety parameters, and structural crash energy management. A more in-depth research project was then conducted in the area of crash energy management design and interior configurations such as seat belt options. Work is continuing in the area with more detailed analyses of crash energy management issues and seat securement systems.

KEY FINDINGS

Because high-speed operations are more likely to automate safety-critical functions, and to rely on advanced communications methods, confidence in the reliability of the equipment and methods is critical.

FUTURE RESEARCH

Track analysis and further model development is planned to continue through FY 1998. Work will also go on in the area of more detailed analyses of crash energy management issues and seat securement systems.



Safety of Mixed Operations can be Assured Through a Detailed Safety Analysis and Risk Mitigation Plan

Drawing Courtesy of Roadway Safety Service, Inc.

Shared Rights-of-Way and Mixed Operations - With the limited availability of new rights-of-way and the high cost of acquiring and building them, when funds are available, the importance of utilizing existing rights-of-way or trackage is key to developing realistic high-speed passenger service alternatives in the United States. However, utilizing rights-of-way or trackage for multiple purposes requires an understanding of the significant potential safety issues and the viable options for their resolution. To facilitate the safe adoption of multiple uses of rights-of-way corridors or trackage, the FRA has undertaken several studies in this topic area.

RESEARCH STATUS

The following reports were completed over the last five years:

Safety of High Speed Guided Ground Transportation Systems: Shared Right-of-way Safety Issues- This report presents the results of a systematic review of safety issues associated with an HSGT system sharing the same right(s)-of-way as other mode(s) of transportation such as automobiles, mass transit systems, commuter rail, intercity passenger rail, freight trains, pipelines, or transmission lines. The report also notes specific risk mitigation options for various operational scenarios.

Safety of High Speed Guided Ground Transportation Systems: Intruision Barrier Design Study - This report documents the results of research into anti-intrusion systems that would perform the function of preventing a derailed railroad car, an errant highway vehicle, or some type of dislodged load from intruding into the operating envelope of an adjacent high-speed line.

High-Speed Passenger Trains in Freight Train Corridors: Operations and Safety Considerations, December 1994 - This report presents the results of a study into operational and technical issues likely to be encountered when planning for high-speed rail passenger service on corridors that currently carry freight or commuter traffic. An analysis in the report establishes a safety performance target based upon present intercity rail operations.

KEY FINDINGS

- Shared Rights-of-Way are feasible for HSGT.
- Risk can be adequately controlled with proper scenario development and mitigation efforts.
- Mitigation against accident occurrence is more effective than consequence mitigation.
- Development of specific mitigation options may require further development.
- Design and construction of effective barriers is feasible for HSGT ROWs.
- Some barrier designs are more cost effective than others and some designs should be abandoned.
- Although mixed operations are feasible for site-specific analyses, these should be used together with appropriate organization, economic, and environmental studies to evaluate actual corridors.

FUTURE RESEARCH

Concern for rights-of-way safety has recently expanded to include security and integrity issues. Research is planned to address the topics of innovative rights-of-way monitoring systems for items such as bridge integrity, wash out conditions, trespassers, and a variety of potential malicious acts that could compromise right-of-way integrity.

Secondly, aerodynamic operational issues resulting from high-speed train development or expansion on existing corridors will be studied. Specifically, window glazing standards will be reviewed and potential safety issues for passengers on platforms of run-through stations will be documented.

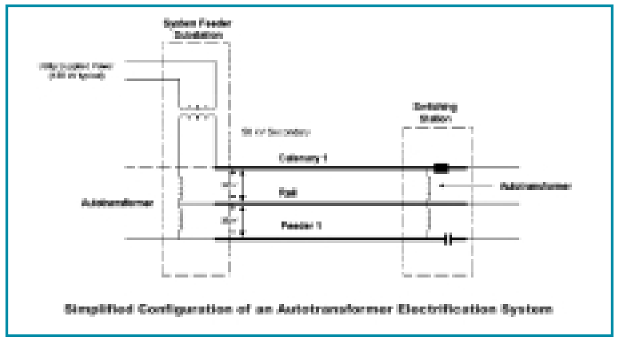
Advanced Planning Will Avoid Unsafe Platform Situations

Electrical Safety - For high-speed rail transportation systems, electrification is often the most efficient method for supplying traction energy to trainsets. Such electrified systems will require substations for processing electric-utility-supplied power, wire networks for electric power distribution along the right of way, means for transferring this wayside power to moving trains, propulsion control of onboard traction motors, and train line power for control and passenger comfort system loads.

Guidelines are required for newly emerging or proposed systems to ensure that the construction, operation, and maintenance of electrified systems will not jeopardize the safety of the general public, passengers, or system employees. The FRA, with support from the National Traction Power Committee (NTPC), has undertaken several studies in this topic area. The NTPC is an organization made up of eleven electrified railroads whose purpose is to enhance and sponsor the exchange of operating and safety procedures relating to the traction power in the transit/railroad industry.

RESEARCH STATUS

FRA/NTPC - Research Needs /Identification of Key Safety Issues Coordination. The FRA and NTPC have had discussions and shared operational and research knowledge in the areas of electrical safety. The FRA has actively participated in NTPC quarterly meetings, and the NTPC and FRA have jointly defined railroad-specific electrical safety research needs.



Simplified Configuration of an Autotransformer Electrification System

Safety Considerations with Railroad Electrification: A Preliminary Review and Assessment, Draft Final Report, June 1996. This report presents the results of a study of safety considerations and analysis of electrified systems. The analysis was directed at identifying and evaluating electrically-related hazards that could be present in such systems for advisory use by new as well as existing operators.

Development of Model Work Rules for Electrified Railway Systems, Draft, March 1996. As part of the preliminary safety study of electrified railroad systems, an initial outline of a prototype set of electrical operating instructions (safety work rules) was developed. These safety work rules were based upon a review of numerous industry standards, available railroad electrical operating instructions and safety rules, government regulations, and other relevant standards. The information presented in this document is for advisory use only by the railroad industry.

KEY FINDINGS

- NTPC serves a valuable function of maintaining and enhancing electrical safety on existing electrified systems and serves as corporate memory on this topic.
- Hazards from electrified railway systems can be maintained at acceptable levels by appropriate system and equipment design and through the development and use of safety rules and safe work practices.
- Foreign electrical safety standards are not necessarily equivalent to U.S. electrical safety standards. Coordination groups between U.S. and foreign standards organizations are forming to harmonize the differing standards.
- Government regulations and industry standards for electrical safety were general purpose and electric utility specific, not railroad specific.

FUTURE RESEARCH

The FRA, Office of Research and Development will continue to maintain a current understanding of electrical safety issues as they relate to high-speed operations.

Catenary Worker on Structure Over Train